Residual Potassium Effects on Corn under No-Tillage

By Frank Yin and Guisu Zhou

The residual effects of long-term surface broadcasting of K fertilizer to preceding cotton provided sufficient K to three successive no-till corn crops.

Production acreage of a specific crop or crop rotation at least partially depends on the crop prices. It has become more common to grow the same crop continuously for several years or even longer on the same fields for optimum profit then switch to another crop due to changes in crop prices. Opportunities to study the nutrient management implications of a cropping change tend to be uncommon. Here, the residual effects of K, surface applied in no-till cotton for 14 years, is examined in successive no-till corn crops planted after cotton.

A cotton trial was conducted at Jackson, TN during 1995 through 2008 to evaluate the effects of K application rates on cotton K nutrition and yield under no-tillage. The soil was a Loring silt loam. The initial Mehlich 1 soil K concentration in 0 to 15 cm depth was 100 mg/kg, which is equivalent to 139 mg/kg under Mehlich 3 extraction in Tennessee. Potassium was applied annually at rates of 0, 28, 56, 84, 112, 140, and 168 kg K/ha in a randomized complete block design with three replicates. The K treatments were broadcast by hand to the soil surface as KCl before cotton planting in each season.

A corn trial was conducted on the same field from 2009 to 2011 with the same experimental design and plot layout used for the previous cotton seasons. No K fertilizer was applied to corn during any of the three years. Corn was no-till planted in 76-cm rows in the same direction as the previous cotton crops. Corn cultivar DKC69-40 was planted at 69,000 to 74,000 seeds/ha. Each year, 3 to 4 weeks after corn planting, UAN was injected 6 to 8 cm deep and 20 cm away from each corn row at a rate of 168 kg N/ha.

Soil Nutrient Concentrations

In the fall of 2008, prior to the initiation of the corn trial, soil K concentrations differed among the historical K application rates (**Table 1**). It was obvious that soil K increased markedly as the K application rate increased. According to the boundaries of soil-test K in low, medium, high, and very high categories of <60, 60 to 96, 97 to 180, and >180 mg K/kg, respectively, under Mehlich 3 for corn in Tennessee (Savoy and Joines, 2009), soil K fertility in the fall of 2008 was in the medium range under zero K, but high with the applications of 28 and 56 kg K/ha, and very high with 84, 112, 140, and 168 kg K/ha.

Compared with the initial soil K concentration of 139 mg K/kg before the initiation of the previous cotton trial in 1995, soil K had decreased under 0 and 28 kg K/ha, but had increased with the 56 kg/ha and above K rates during the 14 seasons of continuous cotton production under no-tillage. Since application of 56 kg K/ha annually was the recommended rate for cotton when a soil tested high in K (Savoy and Joines, 2009), our results showed that after 14 years of K application

Abbreviations and notes: K = potassium; UAN = urea ammonium nitrate; KCl = potassium chloride.

Table 1. Residual effects of K applied to previous cotton crops on Mehlich 3-extractable soil K concentrations during subsequent corn production.

	Mehlich 3-extractable soil K concentrations (fall)			
	2008†	2009	2010	2011
K applied, kg/ha	mg/kg			
0	62g‡	83f	69f	87e
28	98f	103ef	82ef	97d
56	162e	148de	111de	146cd
84	221d	171cd	129cd	187ab
112	259c	205c	140bc	182bc
140	312b	260b	192ab	206a
168	371a	315a	231a	255a
Sig§	***	***	***	***

*** Significant at $p = 0.001$.
† In 2008, a Mehlich 1 extractant was used to determine soil K concentrations. The concentrations were then converted to Mehlich 3 values using the formula: Mehlich 3 K = 1.27 × Mehlich 1 K + 12.0 (University of Kentucky, 2013).
‡ Means in a column followed by the same letter are not significantly different at $p = 0.05$.
§ Sig, significance.

at the recommended rate via surface broadcasting, the soil K concentration was enhanced relative to the initial soil K fertility of 139 mg K/kg in 1995 although the K ratings for 2008 and 1995 both fell in the high category. In contrast, the soil K concentration decreased from 139 to 62 mg K/kg, and the K rating changed from the high category to the lower limit of the medium range, under the zero K treatment during the 14 years of no-till cotton production.

At the end of first year of the corn trial in the fall of 2009, soil K concentration differed among the K treatments (**Table 1**). A similar trend was observed in the fall of 2010. By the end of corn trial in the fall of 2011, soil K concentrations were still different among the K treatments. Applying 28, 56, 84, 112, 140, and 168 kg K/ha resulted in higher soil K concentrations than zero K.

Leaf and Grain K Concentrations

Potassium applied to previous cotton exerted consistent residual effects on leaf K concentrations of subsequent corn at V6 and R1, regardless of year (**Table 2**). As the K application rate went up, the increase in leaf K gradually decreased. However, the residual K effects on grain K were negligible. Unlike soil K, the residual K effects on leaf K did not diminish remarkably with year, regardless of K treatment.

Campbell and Plank (2011) recommended that the range of adequate leaf K concentrations was 20 to 30 g/kg at V6 and 18 to 30 g/kg at R1 for corn grown in the southern U.S.

Table 2. Residual effects of K application rates to previous cotton on leaf and grain K concentrations of subsequent corn from 2009 to 2011.

	-------- 2009 --------		--------------- 2010 ---------------			--------------- 2011 ---------------		
	Ear leaf K R1†	Grain K	Leaf K V6	Ear leaf K R1	Grain K	Leaf K V6	Ear leaf K R1	Grain K
K applied, kg/ha	g/kg							
0	13.3f‡	3.4	11.9f†	13.2f	3.7	8.9f	13.8f	3.6
28	20.9e	3.3	20.7e	17.7e	3.7	19.7e	18.4e	3.4
56	24.0de	3.9	34.5d	22.9d	3.8	34.6d	24.3d	3.8
84	25.7cd	3.5	36.7bc	24.9bc	3.5	39.9a	26.4ab	2.6
112	26.1bc	3.5	39.6ab	24.9cd	3.5	38.5bc	26.3bc	4.2
140	27.8a	3.6	39.6ab	27.1a	3.9	37.6cd	25.9cd	3.8
168	27.7ab	3.5	36.7cd	25.7ab	3.6	39.3ab	27.3a	4.2
Sig§	***	ns¶	***	***	ns	***	***	ns

*** Significant at $p = 0.001$.
† V6, 6-leaf growth stage; R1, silking stage.
‡ Means in a column followed by the same letter are not significantly different at $p = 0.05$
§ Sig, significance.
¶ ns, not significant at $p = 0.05$.

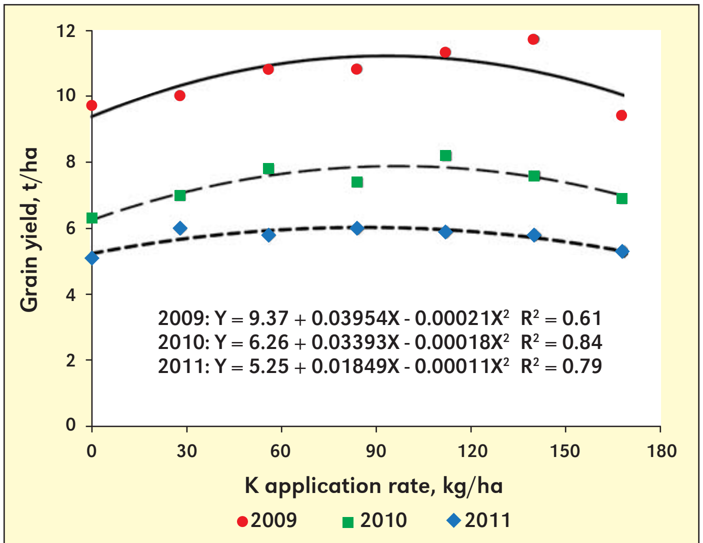

Figure 1. Relationship of grain yields of corn with K application rates to previous cotton from 2009 to 2011.

According to these criteria, leaf K concentrations at V6 and R1 from the zero K treatment were consistently far below the sufficiency ranges, regardless of year, implying that corn plants did not have adequate K nutrition for optimum yield without additional K fertilization in the zero K treatment in this trial. However, leaf K concentrations at both V6 and R1 in all K-applied treatments were equal to or markedly above the lower limit of the sufficiency ranges, depending on the K application rates. Leaf K concentrations at V6 were even greater than the upper limit of the sufficiency range at the 56, 80, 112, 140, and 168 kg/ha K rates due to luxurious uptake. Therefore, corn yield responses to K applications to the previous cotton crop were expected in all three years, based on the obviously deficient leaf K concentrations from the zero K treatment and significant increases in leaf K with K applications, if the recommended adequate leaf K ranges were indicative of final corn yield. Our results suggest that application of K fertilizer at the recommended rate of 56 kg/ha or above to the previous cotton crop via surface broadcasting for 14 continuous years could provide a sufficient amount of K to subsequent no-till corn for at least three years.

Grain Yield

The residual effects of K application rates to previous cotton were not significant on grain yield of subsequent corn in any of the three years (data not shown). Although leaf K concentrations at V6 and R1 were consistently and significantly improved under the K-applied treatments, grain yield at harvest did not benefit from those improvements. However, a significant quadratic relationship was observed between corn yields and K application rates to previous cotton in 2010 and 2011 (**Figure 1**). Generally, corn yield increased as the K rate went up to 94 kg/ha in 2010 and 84 kg/ha in 2011, and then decreased as the K rate increased further.

Potassium Removal by Grain due to Harvest

An accurate accounting of K removal from the soil by corn grain due to harvest is important in corn K management planning. Potassium removal by grain ranged from 2.54 to 3.55 kg K/t of grain at 15.5% moisture with an average of 3.10 kg K/t of grain in our study (**Figure 2**). Our results also showed that the K removal by grain varied with the growing seasons.

Our results are lower than the published grain K removal estimates. For instance, a K removal of 3.96 kg K/t of corn grain was reported in Alabama (Mitchell, 1999). Mallarino et al. (2011) estimated the K removal to be 4.46 kg K/t of corn grain in Iowa. Avila-Segura et al. (2011) found that the K removal was 3.6 kg K/t of corn grain averaged over a 6-yr study in Wisconsin. In the Eastern U.S., Heckman et al. (2001) reported that K removal by corn grain was in the range of 2.67 to 5.19 kg K/t of corn grain with an average of 4.00 kg K/t of corn grain across 23 locations in five states. Preceding measurements of K removal indicate that K concentration in harvested corn grain vary considerably across locations and

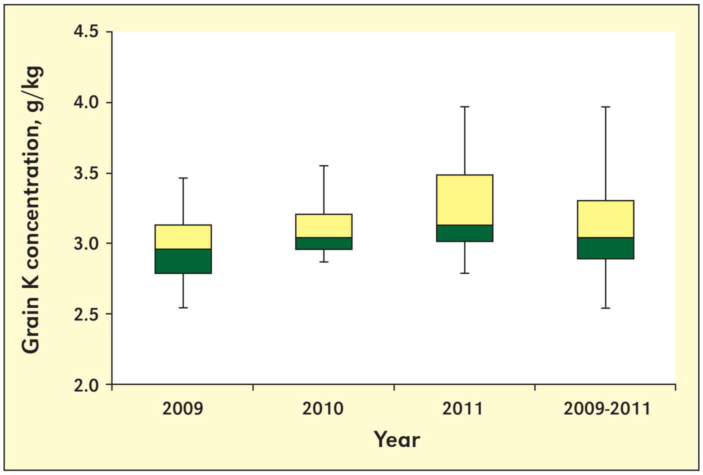

Figure 2. Distribution of corn grain K concentrations within Box and Whisker plots from 2009 to 2011 and the three-year combined data. The median K concentration is shown within the box (interquartile range) while the whiskers represent the upper and lower quartiles of the data.

growing conditions, with some tendency to increase with soil K concentration and corn yield (Heckman et al., 2001).

So far, little is known about the variation in grain K concentration with grain yield of corn. The regression analysis showed that grain K concentration had a quadratic relationship with grain yield in this trial (**Figure 3**). Intermediate grain yields had lower grain K concentrations than the lower and higher grain yields.

Summary

The residual effects of K applications to preceding cotton via surface broadcasting on soil K were noticeable, and were strengthened as the K application rate increased. The K rates applied to previous cotton had consistent residual effects on leaf K of subsequent corn during the early to mid-season. Our results suggest that on no-till fields with high K concentrations, surface broadcasting of K fertilizer at the recommended rate of 56 kg K/ha or above to preceding cotton for over 14 years could provide adequate K nutrition for subsequent corn for at least three years without further K fertilization under no-tillage. Potassium removal by grain ranged from 2.54 to 3.55 kg K/t of corn grain at 15.5% moisture with an average of 3.10 kg K/t of grain, which are lower than the published grain K removal estimates. BC

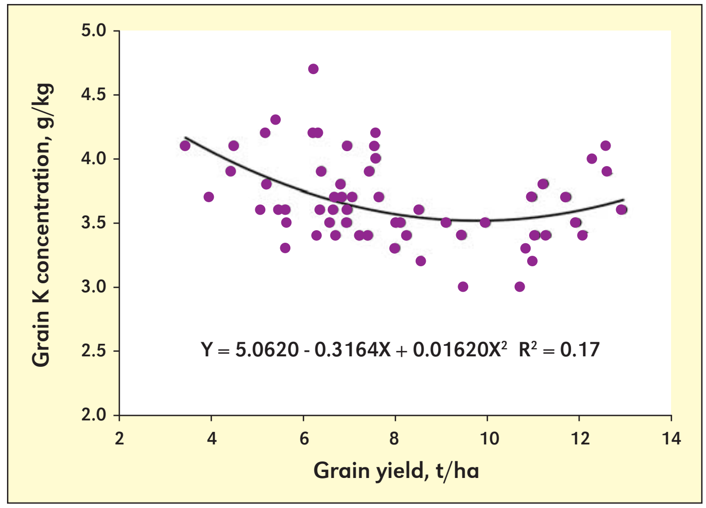

Figure 3. Relationship of grain K concentrations with grain yields of corn on the 2009 to 2011 combined data.

Acknowledgement

Article is adapted from Zhou et al. 2014. Residual effects of potassium to cotton on corn productivity under no-tillage. Agron. J. 1063:893-903.

Dr. Yin is an Associate Professor with The University of Tennessee, Department of Plant Sciences, Jackson, TN; e-mail: xyin2@utk.edu. Dr. Zhou is a lecturer with College of Tobacco Science and Technology, Yunnan Agricultural University, Kunming, China.

References

Avila-Segura, M., P. Barak, J.L. Hedtcke, and J.L. Posner. 2011. Biomass and Bioenergy 35:1190-1195.

Campbell, C.R., and C.O. Plank. 2011. *In* C.R. Campbell (Ed.), South Coop. Ser. Bull. 394. South. Region Agric. Experiment Stn., NC. p. 11-14.

Heckman, J.R., J.T. Sims, D.B. Beegle, F.J. Coale, S.J. Herbert, and T.W. Bruulsema. 2001. Better Crops 85:4-6.

Mallarino, A.P., R.R. Oltmans, J.R. Prater, C.X. Villavicencio, and L.B. Thompson. 2011. Integrated Crop Management Conference, Iowa State University. http://www.agronext.iastate.edu/soilfertility/info/mallarino-2.pdf.

Mehlich, A. 1984. Commun. Soil Sci. Plant Anal. 15:1409-1416.

Mitchell, C.C. 1999. Alabama Cooperative Extension System. ANR-449. http://www.aces.edu/waterquality/articles/0502014/0502014.pdf.

Savoy, H.J., and D. Joines. 2009. Lime and fertilizer recommendations for the various crops of Tennessee. http://soilplantandpest.utk.edu/pdffiles/soiltestandfertrecom/chap2-agronomic_mar2009.pdf. Accessed 31 July, 2013.

University of Kentucky, 2013. Southern Regional Fact Sheet. http://soils.rs.uky.edu/m3vsm1.htm. Accessed 7 August, 2013.